primary numeracy

A review of Australian research

SUSIE GROVES, JUDY MOUSLEY and HELEN FORGASZ report on a national project coordinated by Deakin University. **The project aimed to analyse the last decade of Australian research on primary school numeracy.**

A major policy objective of the Australian Government is to provide all young people with strong foundations in numeracy. This article reports some of the findings from the project entitled *Primary numeracy: A mapping, review and analysis of Australian research in numeracy learning at the primary school leve*l. The project was funded by the Department of Education, Science and Training, under the National Strand of the Numeracy Research and Development Initiative.

The project involved analysing the last decade's Australian research on primary school numeracy, and reviewing it within a broader international context. It involved making research summaries and findings accessible through the development of an indexed electronic database that holds the details of approximately 200 projects and 700 publications. Both this database and the final report were organised using the 'concept map' shown in Figure 1.

Only snapshots of the 270-page report are provided below, with foci on the areas of 'effective teaching', 'concept development', and 'equity'.

Effective teaching of numeracy

There was considerable convergence in the international and Australian research reviewed suggesting that while teaching processes are not easily characterised and differences in learning outcomes are often small, effective teachers:

- have high expectations that all children, at all levels of primary school, will engage seriously with mathematical ideas;
- emphasise the understanding of mathematical concepts and the connections between these;
- structure purposeful tasks that enable different possibilities, strategies and products to emerge;
- choose tasks that are linked to real situations, engage chil-

Assessment	Achievement
	Assessment techniques
	Assessment programs (international, national and state-wide initiatives)
	Diagnostic assessment
	School entry assessment
Broader contexts	Literature reviews
	Major reports
	System initiatives
Classroom practice	Grouping
	Intervention
	Pedagogy
	Resources (teaching aids, technology, textbooks, motivating students, problem solving and investigations, questioning and discussion, real world contexts)
	Teaching strategies
Students	Gifted students
	Informal learning
	Learning styles
	Student attitudes
	Students at risk
Teachers	Pre-service teacher education
	Professional development
	Teachers' beliefs
	Teacher change
	Teacher effects
	Teacher knowledge
Curriculum and processes	Concept development (Algebra, Chance & data, Measurement, Number, Space)
	Curriculum issues
	Developmental frameworks
	Mathematical thinking (children's problem solving, children's thinking and strategies, language of mathematics, visualisation)
	Using mathematics
Equity	Disability
	Ethnicity
	Gender
	Indigenous
	Language factors
	Language background other than English (LBOTE)
	Rural
	Socio-economic status
School community	Community
	Parents
	Primary-secondary transition
	School factors

Figure 1. The primary numeracy concept map; information about each of these topics is contained in the report and the database.

dren, and maintain involvement;
- probe and challenge children's thinking and reasoning;
- build on children's mathematical ideas and strategies;
- are confident in their own knowledge of mathematics at the level they are teaching; and
- use assessment as a basis for development of methods and content, and the identification of problems before they affect further progress.

Luke et al. (2003) have called for renewal of mainstream pedagogy in the middle years, research in order to better understand classroom practice, and emphasis on intellectual demand and student engagement. Many of the possible directions for future research at the primary level identified in the research project resonated with this call.

Concept development

Much of the Australian research reviewed related to a range of issues associated with children's development of particular mathematics concepts. Some of the major findings for selected mathematical concepts are summarised below.

Algebra

Children's knowledge of arithmetic structure provides the foundation for their later understanding of algebra. The research, however, suggested that students fail to abstract the mathematical structures that are necessary for successful transition from arithmetic to algebra. Suggestions for ways to smooth this transition included:
- describing and making use of generalisable processes and structural properties of arithmetic;
- providing classroom activities to address difficulties arising from students' reliance on intuitive language processing;
- focussing on essential aspects of number knowledge, particularly equality;
- building on students' capacity to generalise problem situations, to write equations using variables, and to develop informal concepts of a variable;
- devoting substantial time to discussion about links between problems, processes used by the children, underpinning concepts, and related ideas; and
- using problem situations in measurement and other non-number areas to develop children's ability to think algebraically.

Chance and data

During the past decade, Jane Watson and her colleagues in Tasmania have produced a remarkable body of research into primary school probability and statistics (e.g., Watson & Moritz, 2000; Watson, Collis & Moritz, 1994). They have explored students' understanding of chance in relation to the development of ideas of formal probability and produced a developmental model for its understanding. Using innovative

pedagogies, such as students viewing video recordings of other students' conflicting responses to chance problems and discussing which response they preferred, was found to result in cognitive conflict that improved students' understandings.

Other Australian research in the area of statistics suggested that:

- when dealing with graphs in authentic contexts, students commonly do not
  - appreciate scaling difficulties,
  - identify a graph as relevant in the context, or
  - apply numeracy skills for calculation of data in graphical representations; and
- students need to be challenged in the classroom using non-standard graphs in order to be better prepared for misleading representations.

Given the importance of graphical literacy in both everyday numeracy and numeracy across the curriculum, children's limited understandings in this area suggest that this should be a priority for future research and teacher professional development.

Measurement

Research suggests that teachers are unaware of the importance of structuring their teaching in terms of students' conceptual development in the various sub-strands of measurement. Research on linear measurement indicated that while most high-ability students appear to have an understanding of length, the majority of lower-ability students do not appear to acquire important concepts relating to the linear nature of units. This highlights the importance of devoting sufficient time to the development of underlying concepts before moving to paper-and-pencil activities and formulae.

Number

The prominence of number in primary mathematics was reflected in the quantity of research projects identified in this area. Findings from the extensive body of research suggested that:

- many children are seriously 'under-challenged' in their learning of number in the early years of schooling;
- explicit connections need to be made between concrete materials and the concepts being developed, with further activities to develop and reinforce concepts at a more abstract level;
- teachers' knowledge of the underlying concepts, the use of clear models, and careful bridging from visualisation to numerical forms are important factors in teaching place value and decimals;
- more emphasis is needed on children's understandings of fundamental concepts before the teaching of rules and procedures;
- new symbolic knowledge needs to be coordinated with children's existing informal knowledge and their real-life experiences; and
- the use of calculators as teaching aids can enhance children's conceptual understanding and mental computation before the formal teaching of algorithms.

As a result of their findings, researchers have called for:

- more emphasis on problem solving and abstract mathematics;
- a more holistic approach to the teaching of number, with an emphasis on connections rather than compartmentalised knowledge;
- more focus on children's spontaneous, informal computational strategies;
- greater prominence in school curricula for mental computation at the expense of standard written algorithms; and
- more emphasis on the assessment of mental computation.

Space

Findings from the research on space indicated that:

- positive learning outcomes and teacher satisfaction resulted from the use of a developmental framework and lessons in the *Count me into space* project (Owens, 2000);
- children's interpretations of diagrams can constrain communication in geometry;
- language and experience influence young children's perceptions of shapes, with spatial concepts often being more developed than children can verbalise; and
- teachers need to be more aware of key concepts and experiences that can be drawn out of everyday environments in the early years of schooling.

Equity

The research that made specific comment on equity factors revealed that:

- little is known about the needs of students with specific physical learning disabilities and how to address them;
- efforts have been made to identify and provide remediation for children with numeracy difficulties in the early years of schooling but less has been done to sustain this effort into the later primary years;
- language proficiency, whether English is spoken in the home or not, and other factors such as socio-economic backgrounds affect numeracy achievement;
- gender differences in overall numeracy achievement are virtually non-existent, but gender-stereotyped attitudes and perceptions of girls' and boys' capabilities persist; and
- Indigenous children have different learning needs, and factors that can impede or enhance their learning opportunities have been identified. These include drawing on the strengths of the Indigenous culture, focussing on the children's preferred learning styles, and providing appropriate professional development for teachers.

Conclusion

Overall, we concluded that while there was an impressive array of research reports available to mathematics teachers, researchers and curriculum developers, there are still many areas needing further research and development. The final chapter of the report offers some directions for future research for each of the major areas that comprise the concept map above.

Reference

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